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made and a closer examination would doubtless lead to a moderate change in the thickness of several of the intervals.

The only coal beds which have been opened are Nos. 8, 12 and 18, but none of these was in shape for measurement at the time of examination. No. 12 is exposed in the bed of the run, and its thickness is said to be nearly 3 feet. The coal is clean, free from pyrites and slates, is soft and should yield a good coke. No. 18 was mined for local use at the junction of the forks of Camp creek. Its thickness is said to be 4 feet 2 inches. The coal is soft, clean and is admirably fitted for blacksmiths' use. No. 24 was once exposed near the creek at half a mile below Reed's mill. The thickness is said to be 3 feet.

The following section of the Lower Carboniferous rocks was obtained in passing from Little Bluestone to Mountain creek :

1. Conglomerate.....	20'
2. Imperfectly exposed.....	110'
3. Yellow shaly sandstone.....	45'
4. Concealed.....	25'
5. Gray to yellow shaly sandstone.....	80'
6. Imperfectly exposed.....	85'
7. Conglomerate.....	10'
8. Concealed.....	225'
9. Limestone.....	3'
10. Imperfectly exposed.....	370'
	<hr/>
	973'

Exposures of dark red shales occur frequently in the intervals 2, 6 and 10, and No. 10 is made up almost wholly of such shales. This section brings one to the sandstone which forms the river bluffs in the vicinity of Hinton.

Notes on the Coal-field near Cañon City, Colorado. By John J. Stevenson, Prof. of Geology in the University of New York.

(Read before the American Philosophical Society, October 7, 1881.)

A small area of Laramie rocks lying along the easterly foot of the Greenhorn mountains has escaped erosion. Its shape is irregular and its breadth varies from two to five miles, being greatest at little more than midway north and south. The total area is not far from 70 square miles.

This little field, which has attained much economical importance, owing to the excellence of the coal from one of the beds, is deeply trenched by several streams which flow across it in cañons with walls from 200 to 500 feet high. The more important of these, beginning at the north, are Alkali gap, Chandler creek, Oak creek, Coal creek and Newland creek. Examinations more or less detailed were made in all except that of New land creek.

The strike is almost north and south. The dip on the eastern side is gentle, varying from 3 to 6 degrees, and that side of the trough is the longer one. The axis of the synclinal is distinct, passing at about two miles from the eastern outcrop. The dip quickly becomes abrupt on the western side, being first 7, then 10, then 15 and at last 40 degrees where the outcrop is first reached on Oak creek, but the outcrop lies further west both north and south from Oak creek and the dip becomes sharper and sharper until at last the beds are perpendicular or even pushed over.

The following generalized section of the field was made out; but as no opportunity was afforded to revise the work, it may be defective in some of its details:

1. Sandstones, with some thin shale, not examined in detail.....	400'
2. Sandstone, buff, with occasional pockets of shale.....	45'
3. <i>Coal bed M</i>	Blossom.
4. Shale and sandstone.....	165'
5. Variegated shale.....	170'
6. <i>Coal bed L</i>	4' 2''
7. Shale.....	14'
8. <i>Coal bed K</i>	0' 6''
9. Sandstone.....	25'
10. Variegated shale.....	30'
11. <i>Coal bed J</i>	1'
12. Shale.....	24'
13. <i>Coal bed I</i>	3'
14. Sandstone.....	120'
15. Shale and sandstone.....	25'
16. <i>Coal bed H</i>	5' 3'' to 9''
17. Sandstone and shale.....	46'
18. <i>Coal bed G</i>	1' 10'' to 2'
19. Sandstone and shale.....	30'
20. <i>Coal bed F</i>	4' 6'' to 0''
21. Shale.....	11'
22. <i>Coal bed E</i>	1' 8'' to 6''
23. Variegated shale	30'
24. <i>Coal bed D</i>	1' 10'' to 1' 3''
25. Shale and sandstone.....	25'
26. <i>Coal bed C</i>	4' 6'' to 6''
27. Sandstone and shale.....	50'
28. <i>Coal bed B</i>	4' to 6''
29. Shale.....	30' to 20'
30. <i>Coal bed A</i>	6' to 10''
31. Shale.....	10'
32. Sandstone.....	70' to 100'

The same difficulty was experienced here as in the *Trinidad coal field*,

further south. Limestones are absent and the sandstones show abrupt changes in composition. Direct tracing around the points of bluffs is not always practicable, and identifications of coal beds in different cañons are based largely on the intervals found in the typical section obtained on Oak creek. As these intervals are by no means constant, some of the identifications may prove to be erroneous.

The eastern outcrop of the field is well marked by bluffs and it cannot be mistaken, except in the extreme northern part, where erosion has carried away the lower beds and the bluffs contain only the higher members of the series. The sharp hogbacks in which the beds are turned up at angles varying from 40 to 90 degrees, mark the western limit sufficiently well, except in the southern part of the field where erosion has beveled off the surface of the mesa. But even there, exposures are found on the larger streams which enable one to follow out the limit with but little difficulty.

Coal mines have been opened at several localities along the eastern side of the trough and branch roads have been constructed by the Atchison, Topeka and Santa Fé and the Denver and Rio Grande railroad companies, leading to mines owned or controlled by those companies. Insignificant openings only were seen along the western outcrop, but some pits on the northern side of the field have been worked somewhat extensively to supply Cañon City.

Exposures are infrequent on the northern edge of the field, where a deep covering of gravel conceals all the rocks even to the tops of the hills; while beyond the sharp ridge bounding the field, a basin has been eroded and rocks are rarely seen in place. The few openings seen afforded no data for determining the position of the beds in which they have been made. A similar difficulty was encountered on the north-eastern side of the basin where the lower beds of the series are buried under the alluvial coating of the plain, and only the higher beds are shown in the bluffs. Some *coal* blossoms and an extensive opening were seen here, but their position was not determined, further than they belong to the upper part of the section.

Alkali Gap. The stage-road leading from Cañon City to Silver Cliff passes through this gap at about 4 miles from Cañon City. The exposures are excellent for a distance of nearly 400 yards, but as soon as one enters the basin into which the gap opens, all exposures cease. The following section was obtained in this gap, the thicknesses of the several beds being determined by pacing and calculation from the dip:

1. Conglomerate.....	239'
2. Sandstone.....	168'
3. Concealed.....	40'
4. Sandstone.....	128'
5. Shale.....	3'
6. Sandstone.....	69'
7. Concealed.....	42'

8. Sandstone.....	6'
9. Concealed.....	122'
10. Sandstone.....	10'
11. Concealed.....	12'
12. Sandstone.....	8'
13. <i>Coal bed</i>	5'
14. Sandstone.....	6'
15. Concealed.....	20'
17. Shale.....	5'
18. <i>Coal bed</i>	2'
19. Imperfectly exposed, much whitish sandstone...	75'
20. Sandstone.....	10'
21. Concealed.....	160'
22. <i>Coal bed</i>	3' 2''
23. Clay.....	1'
24. Sandstone.....	30'

With this all exposures cease along the line examined, but Mr. Alex. Bowie, local superintendent of the coal mines at Rockvale on Oak creek, states that another bed of *coal* has been seen by him below the sandstone. Unfortunately no determination of the distance was made by him.

The conglomerate at the top of the section is very coarse and altogether unlike any rock seen elsewhere in the field. If Mr. Bowie's observations be accurate, this rock is higher in the series than any exposed in the typical section obtained on Oak creek and it has been eroded from the mesas in the southern part of the field, from Chandler creek southward. The sandstones down to No. 12 are soft, with a yellowish tint and readily disintegrate when exposed to the weather. Thin beds of shale occur here and there in the upper part, but are not persistent and they have been ignored in making up the section.

The *Coal bed*, No. 13, is exposed at the roadside as one enters the gap from the west. Its dip is 85 degrees at the top of the shaft and 75 degrees at the bottom. No detailed measurement was made as the shaft has been abandoned and the edge is unsafe. The bed shows five benches of *coal*, with a layer of dark shale fully 5 inches thick. A parting of sandy clay, nearly 2 inches thick, appears to be persistent. *Coal bed*, No. 18, has been opened by a shaft probably 20 feet deep. The dip is irregular but is somewhat more than 75 degrees. The *coal* so far as exposed is friable and worthless. No bed was seen between this and No. 24, but Mr. Bowie states that another bed exists in this interval and that it is shown at a little way from the line followed. It is 1 foot 7 inches thick and contains very fair coal. No. 22 dips at 85 degrees, almost due east; it is in four benches, separated by thin partings of sandy shale. It has been opened by two shafts, each about 20 feet deep; but the coal as far as seen is badly broken by exposure to the weather.

In the absence of detailed measurements below the bed, No. 22, one may not undertake to identify these beds with any in the Oak creek section;

but it may be that they represent *Coal beds* C, I and L. The associations of the lowest bed suggest reference of it to *bed* C.

Chandler creek. The cañon of this stream crosses the field and affords very fair exposures of the upper part of the section ; but erosion has been active at both ends of the cañon, so that the lower beds have been removed and for the most part they are now buried under gravel on the broad elevated terracé. A boring made at the mouth of the cañon, at a little way east from the foot of the bluffs, begins in sandstone, No. 14 of the general section, and continues to the depth of 301 feet 9 inches. The record of the boring as furnished by Mr. Alex. Bowie, is as follows :

1. Gravel.....	30' 6"
2. Sandstone.....	40'
3. Shale.....	7' 6"
4. Sandstone.....	1' 4"
5. Shale.....	6' 10"
6. <i>Coal bed</i>	4' 1"
7. Hard sandstone.....	3' 9"
8. Soapstone.....	52'
9. Sandstone.....	6'
10. Soapstone.....	58' 4"
11. Sandstone.....	5' 4"
12. Shale.....	48' 2"
13. <i>Coal bed</i>	5' 5"
14. Soapstone....	8' 9'
15. Sandstone.....	2'
16. Soapstone....	1' 4"
17. Sandstone.....	6'
18. Sandstone and shale.....	14' 5"

The upper bed seems without doubt to be *Coal bed* H, though it is much thicker here than at any other locality examined. The structure as shown in the boring is :

Coal, 1' 3"; clay, 11"; *coal*, 1' 11".

The lower bed is usually thought to be the same with *Coal bed* A, the bed mined on Coal creek by the Colorado Coal and Iron Company, but the interval to the upper coal is very nearly the same with that obtained between *Coal beds* H and C on Oak creek, barely a mile away ; so that the lower bed is more probably *Coal bed* C, the bed worked in shaft No. 2 of the Cañon Coal Company. Its structure as shown in the boring is :

Coal, 3' 4"; clay, 11"; *coal*, 1' 2".

A number of borings have been made along Chandler creek, but the records are not accessible. The trough becomes deep in this cañon, and at the bottom of the synclinal, *Coal bed* A is fully 800 feet below the surface. The walls of the cañon are low and the cañon itself is very broad, especially near the line of the axis. No trace of the great conglomerate of Alkali gap was observed here.

Beyond the axis of the synclinal, the rocks rise rapidly westward and at the head of the cañon one is brought very near to the horizon of *Coal bed H*. An opening has been made in a bed at a little way beyond the head of the cañon, but in the absence of all exposures near at hand, the place of the bed could not be determined. The lowest sandstone of the group is reached at a short distance beyond and shows the same features as those to be described on Oak creek. The middle Cretaceous rocks lie immediately behind the great sandstone and continue thence to the foot of the mountain, where the Dakota rests on the metamorphic rocks. The transition from the Coal group to the Fort Pierre is very gradual and no line of separation can be found.

Oak creek. The cañon of this stream follows a north-easterly direction across the field and affords by far the best series of exposures. It is followed by the Coal branch of the Atchison, Topeka and Santa Fé railroad to Rockvale, where the Cañon Coal Company has sunk the shaft, No. 1, with the view of working *Coal bed A*. The outcrop of that bed is poorly shown in this cañon along the eastern side of the field, but that of *Coal bed C* is frequently exposed. Shaft No. 2 of the Cañon Coal Company opened this bed and a slope is under way to reach the same bed for the Colorado Coal and Iron Company. The section at shaft No. 2, including the measurements in the shaft, is as follows :

1. Sandstone, seen on the bluff.....	15'
2. Shales.....	10'
3. Concealed to curb of shaft as estimated from the dip.....	120'
4. Clay and gravel in shaft.....	30'
5. Shale and thin sandstone.....,.....	31'
6. <i>Coal bed E</i>	1' 6"
7. Shale and thin sandstones.....	47' 6"
8. <i>Coal bed C</i>	4' 6"
9. Fireclay.....	0' 5"

A coal blossom, indicating a thickness of about 8 inches, was seen at a few rods east from the shaft. Allowing for the dip, this bed belongs near the middle of the gravel at the top of the shaft, and is therefore *Coal bed G*. *Coal bed E* contains very good coal, but as it is not of workable thickness, no tests have been made to determine its value. *Coal bed C* is mined in the shaft where its structure is

Coal, 2' 2" ; clay, 2" ; *coal*, 1' 9" to 2' 2".

An outcrop on the opposite side of the valley shows the bed 3 feet 10 inches thick, as reported by the local superintendent of the company, and there the parting is present also. But lower down the stream the bed becomes very thin and at several exposures it is insignificant. In the shaft it yields an excellent coal, which is hard, must be blasted but comes out in large blocks. The underlying fireclay aids much in mining, but it is soft and is likely to be a source of annoyance in the immediate vicinity of the shaft. The dip is a little south of west at 5 degrees.

The sandstone, No. 1 of the section, caps the bluff directly north from the shaft and is easily followed to Rockvale, where it is alongside of the railroad. The Cañon City Coal Company's shaft No. 1 begins in this rock. A boring was made in creek bottom at about 500 feet from the shaft and it begins in this rock, though somewhat higher than the top of the shaft. The record of the boring is

1. Sandstone.....	82'
2. Shale.....	17'
3. White sandstone.....	7' 3"
4. <i>Coal bed H</i>	0' 9"
5. Sandstone.....	10' 3"
6. Soft shale.....	4'
7. Sandy shale.....	31' 4"
8. <i>Coal bed G</i>	1' 4"
9. Sandstone, hard.....	15' 5"
10. Argillaceous shale.....	3' 8"
11. Sandy shale.....	18'
12. <i>Coal bed E</i>	0' 6"
13. Sandstones and shales in thin beds.....	52' 8"
14. Black shale.....	5' 4"
15. Sandstone.....	2'
16. <i>Coal bed C</i>	0' 8"
17. Sandstone and shale.....	3' 7"
18. Black shale.....	21' 3"
19. Sandstones and shales.....	20' 10"
20. <i>Coal bed B</i>	0' 6"
21. Black shale.....	22' 1"
22. <i>Coal bed A</i>	3' 4"
23. Arenaceous shale.....	9' 7"
24. Black shale.....	5'
25. Sandstone and sandy shale.....	5' 1"
Total.....	341' 6"

The company's shaft at the time of examination was down 220 feet. *Coal beds G and H* are thicker in the shaft than in the boring, the former being 1 foot 2 inches and the latter 1 foot 10 inches. The great sandstone, No. 1 of the section, is nearly 120 feet thick. It varies somewhat in structure, as is well shown in the railroad cut at Rockvale. In the boring it seems to be a compact sandstone throughout and it shows a similar structure in the shaft, but in the railroad cut, only a few yards from the shaft it becomes shaly toward the middle, there being not less than 29 feet of shale exposed in the cut. The rock is mostly massive, soft and reddish-yellow to buff and bluish gray. It contains vast numbers of *Halymenites major*, of which excellent specimens can be obtained at Rockvale. This fossil is most abundant in the upper part of the rock.

The bluff immediately north from the shaft at Rockvale affords good exposures of the overlying beds. The section obtained on this bluff is as follows:

1. Sandstone..... 20'
This is buff, soft, weathering with honeycombed surface, but contains a hard reddish band, only a few inches thick.
2. Sandstone..... 45'
Very like the last, but containing some shale, which decreases westward until both sandstones are practically one.
3. *Coal bed M.*..... Blossom.
This may be only a carbonaceous shale.
4. Shales and sandstone..... 61'
Where the section was taken this seems to be almost wholly variegated shale, but within 50 yards it has a bed of massive sandstone, buff or yellow, soft and covered with a thin band of hard red sandstone.
5. Sandstone..... 8'
Yellow, where examined, more or less ferruginous, with small nodules of carbonate of iron; at a little distance further up the creek, it becomes buff like the higher beds and weathers into rounded bosses. This is a marked and persistent bed, which remains above the surface to the bottom of the synclinal at the forks of the creek. It has on top a thin bed of flaggy red sandstone, which is very hard.
6. Shale..... 87'
Variegated, with some thin beds of sandstone, 1' to 2' thick, which are more or less argillaceous; here and there is a band of carbonaceous shale; possibly some coal may belong in this interval but none was recognized.
7. Sandstone..... 9'
Very like No. 5.
8. Shales..... 186'
Variegated; for the most part well exposed, but the exposure is incomplete toward the base, where two black streaks were seen, the blossoms of *Coal beds K* and *L*. This mass is persistent. It passes below the surface before the synclinal axis is reached, but re-appears on the west side in the bluff at the head of Oak creek cañon.
9. Sandstone..... 25'
Hardly differing in general features from No. 5.

- | | |
|--|--------|
| 10. Variegated shales | 30' |
| 11. <i>Coal bed J</i> | 0' 10' |
| Represented only by carbonaceous shale, where the section was measured ; but it has been opened elsewhere on the bluff, with a thickness of 1'. | |
| 12. Shale..... | 24' |
| At the base of this is a very friable sandstone, almost white, which is persistent. | |
| 13. Concealed..... | 25' |
| This is calculated from the dip as the interval between the base of No. 12 and the top of the sandstone in which the shaft begins. Exposures in the vicinity indicate that this is occupied in part at least by shales at the base of which is <i>Coal bed I</i> . That bed is not exposed here. | |

This bluff is continuous to the cañon of Chandler creek, and the same section is exposed at the mouth of that cañon. The sandstones of the section are all light yellow or buff, and almost without exception have a band of hard red flaggy sandstone as the top layer. Search was made in all these red beds, but no fossils were found aside from the *Halymenites*, and that has its upper limit in the great sandstone at the top of the shaft. Occasional impressions of fossil dicotyledonous leaves were seen, and a fine *Sabal* has been brought out of the shaft No. 1. The dip here is somewhat more than 3 degrees and almost due west.

South Oak creek enters the main stream at Rockvale and flows northwardly. The great sandstone with *Halymenites* continues in sight along this stream for nearly two miles. At the first fork of the stream the top of that rock is reached, and there *Coal bed I* is well exposed, with the following structure :

1. <i>Coal</i>	8½"
2. Clay.....	½" to 1"
3. <i>Coal</i>	9½"
4. Sandy clay.....	1" to 1½"
5. <i>Coaly shale</i>	2" to 4"
6. <i>Coal</i>	11" to 13"
Total	2' 11"

The coal is evidently poor throughout. The bed is overlaid with shales succeeded by the friable white sandstone seen near Rockvale. Streaks of coal are shown in the shale at a little way further up the creek. At say a mile further up the main stream its cañon and that of a gulch leading into Bluff Spring park, a tributary to Coal creek, come very closely together. There the shales, No. 8 of the Rockvale bluff, are reached, but no exposure of *Coal beds K* and *L* was found.

Following up Oak creek above Rockvale, one sees the rocks descending, until the sandstone, No. 5 of the Rockvale section, is the lowest bed ex-

posed. Near the line of the synclinal axis a cañon opens from the north, at whose head is a fine exposure of the higher beds. But there was no opportunity to examine this in detail, and the thickness of the beds overlying the Rockvale section was estimated at 400 feet. They are chiefly buff sandstones, with comparatively thin beds of shale, which vary greatly in thickness and may be regarded only as partings of the sandstone. No traces of coal have been observed in these higher beds. The synclinal axis crosses Oak creek very near the forks of the stream.

A boring was made some time ago by the Colorado Coal and Iron Company on Oak creek, at a little way below the crossing of the synclinal. The curb of the boring is but a few feet under sandstone, No. 5 of the Rockvale section, and *Coal bed A* was reached at 571 feet. The record of the boring is not accessible and the depth is given according to indirect information.

The section to *Coal bed H* is shown in the bluff at the head of Oak creek cañon, and that *coal bed* was opened some years ago, by Mr. Nelson, just south from the cañon; but the opening was abandoned, owing to inferiority of the coal. The condition of the pit when visited was not such as to afford exact measurement. The bed is said to be 5 feet 3 inches thick, with a shale parting near the middle. Drab shales overlie it, separating it from the light gray sandstone, above which, at a few feet, is the great yellow sandstone. When freshly mined, the coal is said to look well, but after short exposure it slakes. The dip at this pit is eastward at nearly 40 degrees.

At nearly a mile further south along the bluff, *Coal bed I* was seen above the yellow sandstone, showing:

<i>Coal</i>	1''
Clay	1'
<i>Coal</i>	1' 2''

But the crop coal is very poor. Higher up on the hill-side, *Coal bed K* was seen 6 inches thick, while at a few feet higher is *Coal bed L*, showing:

<i>Coal</i>	2' 6''
Clay	6''
<i>Coal</i>	1' 3''

The bed makes a formidable blossom, but the exposure does not suffice to indicate the quality of the coal. The great mass of shale, No. 8 of the Rockvale section, contains much friable sandstone here, which breaks down even more readily than the soft clay shales seen further down the creek. The sandstone, No. 5 of that section, is persistent here and is easily recognized, though it is somewhat harder than at Rockvale.

The outcrop of *Coal bed A* is shown in a low ridge west from the Nelson opening, and the road leading to Mr. Bishop's ranch passes over it. The exposure is imperfect here and the bed is much better shown at a little way further north, where it was opened by Mr. Bassick near the stone cabin. This opening was abandoned because the abrupt dip, more than

40 degrees, made raising the coal by horse-power too difficult for profit. The crushed outcrop at this pit shows a thickness of nearly 20 inches, but the bed is said to show 3 feet of good coal at the end of the slope. The overlying shale is thin and is covered by a yellow sandstone.

A low mound rises in the park between this ridge and the bluff. A *coal blossom* was seen here, but its place was not determined, though the bed is probably C. The blossom indicates not much coal.

Followed southward the yellow sandstone associated with *Coal bed A* is seen forming a sharp low ridge, which continues southward to the head of Oak creek, where it is lost in the mesa. At the head of Oak creek cañon a park intervenes between the bluff and the sandstone ridge; but southward the park becomes narrow and at length the mesa and the low ridge are united. An exposure on Mr. Bishop's ranch, near the point of union, shows the following section :

1. <i>Coal bed C</i> ?	0' 7"
2. Shale and some sandstone.....	22'
3. <i>Coal bed B</i> ?.....	0' 2"
4. Shale	36'
5. <i>Coal bed A</i>	3' 10"
6. Shales, sandy, not fully exposed.....	15'
7. Deep yellow sandstone, estimated.....	100'

The identification of the smaller coals is only provisional, there being no other detailed measurements on this side of the field for comparison. The coal of bed A appears to be by no means bad and the crop coal has a bright fracture. The dip is vertical here and the bed can be followed easily from this place to where it passes into the mesa.

The sandstone below the coal is the lowest bed of the Coal group. The upper part is hard sandstone, honey-combed with films of quartz, and holds thin beds or pockets of conglomerate in which the pebbles vary in size from buckwheat to pea. The color varies from cream to deep reddish yellow, and in most respects the rock is an almost exact duplicate of the Dakota sandstone, which is exposed within a short distance at the foot of the Greenhorn mountains. The lower part of the mass becomes more or less shaly, and at length passes into a series of dull reddish shales, somewhat sandy but mostly argillaceous, and showing little structure. These in their turn pass almost imperceptibly into the Fort Pierre shales, which are well exposed at the head of Oak creek, where they hold the customary septaria and abundance of selenite. The thickness of the dull beds below the sandstone was not measured on Oak creek, but it appears to be not far from 100 feet.

The Niobrara and Fort Benton groups are fairly well shown at the head of the creek and as far down as Mr. Bishop's ranch; but no effort was made to determine their thickness. The Dakota is exposed on a tributary of Oak creek, where it is said to contain a thin bed of fairly *good coal*. This has been opened and the whole space underlaid by the Dakota has been taken up as coal land. The guide was unable to find the opening,

but there seems to be no doubt that it exists and that the coal is there. The upper member of the Dakota shows the usual features, but the lowest member is a coarse conglomerate, 10 or 15 feet thick, which is made up of fragments of the coarse gneissoid granite on which it rests. These fragments have suffered little from water, and the conglomerate can be distinguished only with difficulty from the underlying granite.

No exposures occur on the mesa between Oak creek and South Oak creek, aside from fragmentary exhibitions of sandstones, which barely suffice to indicate the dip, and give no information respecting the succession of the beds.

Coal Creek.—Coal creek is followed by a branch of the Denver and Rio Grande railroad, leading to the mines of the Colorado Coal and Iron Company. One branch of the stream flows northward along the eastern edge of the field, while several tributaries flow to it from the west, each of which has eroded a cañon, exposing a large part of the section. Examinations were made along several of the streams.

At the mines of the Colorado Coal and Iron Company, on Coal creek, the following exposure was found :

1. <i>Coal bed C</i>	0' 8"
2. Shale and sandstone.....	50'
3. <i>Coal bed B</i>	0' 10"
4. Shale.....	30'
5. <i>Coal bed A</i>	6' 2"

And the dip is N. 30° W. mag.

Coal bed C, the same with that mined in shaft No. 2 of the Cañon City Coal Company, on Oak creek, is represented here only by a little carbonaceous shale. *Coal bed B* is well shown on the face of the bluff, and descends with the road from the top of the hill. *Coal bed A* is mined extensively and yields a superior coal, which is used in the railroad engines and is shipped largely to be used as fuel at Denver and other cities of Colorado. The bed shows the following structure at the mouth of the slope :

<i>Coal</i>	1'
Clay	7"
<i>Coal</i>	4' 7"

At half a mile further up this branch of Coal creek, the same bed is mined by the Grand Cañon Coal Company. The bed was not measured here, but the thickness is reported by the President to be 3 feet 6 inches, and the quality is regarded as equal to that of coal from the other mine. Only the lower division of the bed is present in the slope. The upper division is merely a "rider" coal, and the interval between it and the main body varies from zero to 11 feet ; the latter interval being seen at the Cassidy slope, while the two divisions are in contact at many places in the Colorado Company's mine. The rider is distinctly shown in the gulch at the Cassidy slope.

Following up the gulch for half a mile, the following section was obtained :

1. Sandstone.....	15'
2. Shale	2'
3. <i>Coal bed G</i>	0' 6"
4. Shale and thin sandstone.....	15'
5. Sandstone.....	5'
6. Black shale	8'
7. <i>Coal bed F</i>	4' 6"
8. Bluish shale.....	11'
9. <i>Coal bed E</i>	1' 8"
10. Variegated shale.....	28'
11. <i>Coal bed D</i>	1' 3"
12. Shale and thin sandstone.....	25'
13. <i>Coal bed C</i>	Blossom.
14. Sandstone and shale, estimated	45'
15. <i>Coal bed B</i>	1' 2"
16. Shale	16'
17. <i>Rider coal bed</i>	0' 10"

Coal bed B is shown on the low hill alongside of the road, at a few rods above the trestle ; it seems to be hard and fairly clean coal. The upper part of the interval, No. 14, is occupied by a massive, soft, yellowish white sandstone, which is about 20 feet thick. *Coal bed C* is represented by carbonaceous shale, which was followed up the gulch to where it passes under the surface. The interval between it and *Coal bed D* was estimated. The rest of the section was obtained on a projecting point opposite a gap in the hill, lying between the road and the gulch. *Coal bed D* is shown on both sides of the stream, but is thicker on the southerly side, where it shows 22 inches of coal.

Coal bed F appears on the bluff, where its blossom measures 4 feet 6 inches, but a good exposure occurs at a few yards further up the gulch, which exhibits the structure of the bed in detail as follows :

<i>Coal</i>	0' 5"
Parting.....	— —
<i>Coal</i>	1' 7"
Clay	0' 2"
<i>Coal</i>	0' 9"

The coal is sulphurous and dirty, so that it is of little value. The overlying shale is fissile and very black. *Coal bed G* is exposed under the edge of the sandstone which caps the bluff. This rock is reddish-yellow, mostly massive and occurs in cliffs. The thickness appears to be upwards of 40 feet, but exposures further south show that *Coal bed H* belongs at but a little way above *Coal bed G*, and the thickness of the lower sandstone is not more than 15 feet. The rock above *Coal bed H* is the one form-

ing the top of the mesa, and its cliff is shown at a little way back from the top of the bluff overhanging this gulch.

Crossing the narrow divide to Bluff Spring park, one passes over the great sandstone in descending to the park. The spring issues from almost directly underneath the sandstone, No. 1 of the last section, but *Coal bed G* is not exposed. The sandstone overlying *Coal bed F* caps a little mound in the park, and that *coal bed* has been exposed there with a thickness of 2 feet 6 inches. The overlying shales are not black, the carbonaceous matter having disappeared. The road leading from Bluff Springs park to the Shaw gulch passes under a bluff, immediately beyond the park, where *Coal beds E* and *F* are exposed. The latter is but 1 foot 6 inches thick, but the former shows:

Coal, 8''; clay, 4''; *coal*, 1'.

The coal is very poor. The shale above *Coal bed F* is brown and yellow, carbonaceous matter being wholly absent. No prospecting has been done in Bluff Spring park below the line of the wagon road, and *Coal bed A* has not been recognized.

The massive yellow sandstone overlying *Coal bed H* is easily followed across the low divide separating Bluff Spring park from the Shaw gulch. In this short gulch, the Cañon Coal Company have mined *Coal bed F*, known as the *Shaw coal*. The coal has been hauled 4 miles in wagons, to be shipped at Rockvale. It underlies a thin gray sandstone and the shales intervening are lead-colored. The structure of the bed as shown in the mine is:

<i>Coal</i>	0' 7''
Parting.....	— —
<i>Coal</i>	1' 5''
Parting.....	— —
<i>Coal</i>	1' 4''

The thickness in this mine varies little from 40 inches. The coal is good and has been used extensively on the engines of the Atchison, Topeka and Santa Fé railroad; but the engineers think it inferior to coal from *bed A*.

Coal bed G is found here at 22 feet above *F* and is insignificant. *Coal bed H* is very thin and but 17 feet above *G*. The Great sandstone forms a bold cliff here and, according to Mr. Bowie's measurement, it is 75 feet thick, thus showing a decided diminution in thickness southward. *Coal bed I* rests on the sandstone and, where explored immediately north from the Shaw gulch, is 22 inches thick.

The next gulch southward is that known as Bailey's gulch. It is barely half a mile from the Shaw gulch and affords a good exhibition of the measures. The following section was measured there by Mr. Bowie, who has kindly given me the use of his record:

1. Black shale.....	3'
2. <i>Coal bed K</i> ?.....	3'

3. Shale.....	0' 6''
4. Gray sandstone.....	10' 6''
5. Black shale.....	1'
6. <i>Coal</i> , divided midway by shale, 1'', J.....	2' 5''
7. Shale and gray sandstone.....	18' 3''
8. <i>Coal bed I</i>	0' 3''
9. Shale.....	1'
10. Gray sandstone.....	13' 6''
11. Yellow sandstone.....	60'
12. Shale.....	1'
13. <i>Coal bed H</i>	0' 6''
14. Shale.....	1' 6''
15. Gray sandstone.....	15'
16. <i>Coal bed G</i>	1' 6''
17. Shale.....	1'
18. Gray sandstone.....	7'
19. Black shale.....	14'
20. <i>Coal bed F</i>	3' 4''
21. Shale.....	7' 9''
22. Sandstone.....	4' 6''
23. Shale.....	8' 6''
24. <i>Coal bed E</i>	1' 6''
25. Shale.....	38' 3''
26. <i>Coal bed D</i>	3'
27. Interval.....	61'
28. <i>Coal bed B</i>	4'
29. Argillaceous shale.....	30'
30. <i>Coal bed A</i>	0' 10''
31. Shale.....	0' 10''
32. Argillaceous sandstone.....	14' 6''
33. Yellow sandstone.....	150'

The lettering of the coal beds is in accordance with the generalized section. *Coal bed C* is not given in this section; it is exposed at the point of the bluff between Bailey and Shaw gulches at 33 feet above *Coal bed B*. An imperfect exposure made with the hammer showed 2 feet of coal, but neither the top nor the bottom of the bed was reached.

Coal bed G varies from 2 inches to 18 inches. *Coal bed F* is well shown in the bed of the gulch, where the structure is clearly the same as in Shaw gulch. *Coal bed E* is imperfectly exposed in the stream bed; but *Coal bed D* is well shown in the side of the gulch where it has been prospected. *Coal bed B* has been opened at the end of the bluff where the thickness is as given. *Coal bed A* is utterly insignificant here, being but 10 inches in Mr. Bowie's section and 14 inches where seen in the gulch by the writer.

The great sandstone at the base of the section is reached just east from the mouth of the gulch. It has the same characteristics everywhere along the east face of the field. The thickness as given by Mr. Bowie is per-

haps the extreme, for the mass is not invariably a compact sandstone, but often shows great beds of sandy shale, sometimes even clay shale, the whole merging into the clay beds or beds of passage to the Fort Pierre shales.

Newland Creek. This is the next stream southward and makes a cañon across the whole of the field. But no detailed examinations were made there. A distinct though gradual rise of the whole basin southward carries out the highest members of the series before Newland creek is reached, so that almost midway in the basin, the great sandstone with *Halymenites* is at the top of the mesa. The measures above that sandstone are probably not more than 150 feet thick and no exposures were found to yield a section. Mr. Bowie's observations along the eastern face of the field at and beyond Newland creek show that the *coal beds* become thicker than they are further north, as indeed is suggested by the section in Bailey's gulch. A thick bed is worked on a tributary to Newland creek, which Mr. Bowie thinks is equivalent to the Shaw coal. The section of the bed as given by him is:

Coal.....	1' 8"
Clay.....	0' 7"
Coal.....	2'
Shale.....	1' 2"
Coal.....	1'

RELATIONS OF THIS FIELD.

Careful search was made everywhere for fossil remains, but nothing was found aside from the fucoid, *Halymenites major*, and some palm leaves. *Halymenites* occurs abundantly in the sandstone overlying *Coal bed H*, and a few specimens were observed in the sandstone at the base of the series, which was examined at but two localities. The palm leaves were obtained in the Rockvale shaft, at fully one hundred feet below *Coal bed H*. The thickness of measures included between the upper and lower limits of the fucoid is more than four hundred feet.

This distribution of the fucoid is of no little interest. The writer* has shown that along the South Platte river, north from Denver, *Halymenites* occurs throughout a great mass of sandstone, where it is associated with forms proving the rock to belong to the Fox Hills group of the Upper Cretaceous. Dicotyledonous leaves occur there in the same sandstone.

In the Trinidad coal-field of southern Colorado and northern New Mexico, the writer† recognized a persistent sandstone, 60 to 80 feet thick, as marking the base of Laramie group. This sandstone, which occasionally holds a coal bed, contains *Halymenites major* in profusion, while that fossil occurs neither above nor below this horizon. At one locality, the sandstone contains a *Cardium*-like mollusk, but the specimens obtained are too indifferent for specific determination.

* Am. Journ. of Science, 3rd Series, Vol. xvii, p. 370.

† Amer. Journ. of Science, 3rd Series, Vol. xviii, p. 132.

Along Galisteo creek, in central New Mexico, as well as on the Rio Grande, 100 miles further south, the writer has sought in vain for specimens of the *Halymenites*, both in 1879 and 1881. The fucoïd seems to be wholly wanting in the Laramie area of central New Mexico.

Comparing the distribution at the several localities mentioned, we have as the vertical extent of the fucoïd :

In northern Colorado, along South Platte.....	700'+
In central Colorado, Cañon City field.....	400'
In southern Colo. and northern N. M., Trinidad field.	80'
In central New Mexico, Galisteo creek and Rio Grande.	0'

Halymenites major, along the eastern foot of the Rocky mountains, is as thoroughly diagnostic of the Fox Hills group a *Arthropycus harlani* is of the Medina sandstone in the Appalachian region. The *Halymenites* sandstone of the Trinidad field, the lower 400 feet of the Cañon City column, and the enormous mass of sandstone on the South Platte, below St. Vrain's creek, are equivalent and represent the Fox Hills group, as generally accepted. Coal occurs in them all, but most abundantly in the Cañon City area. It should not be forgotten, however, that the South Platte locality is at 70 miles from the mountains. When the section has been made from the mountains to that locality, not a little of the productive coal series will be found represented on the Platte by this sandstone group.

The Fox Hills group, as generally accepted, thins out southward and finally disappears before reaching central New Mexico.

Stated Meeting, October 21, 1881.

Present, 15 members.

President, FREDERICK FRALEY, in the Chair.

Mr. Aubrey H. Smith presented his photograph for the album.

Letters of envoy were received from the Second Geological Survey of Pennsylvania, the Johns Hopkins University, and the Geological Survey of the United States.

Donations to the Library were received from the Gazette Hongroise; J. M. Schary's heirs, Prag; Royal Institute, Venice; Revue Politique; Royal Academy, Brussels; Nature; Essex Institute; S. H. Scudder; Board of Education, Providence, R. I.; Wesleyan University; Silliman's Journal; New York Academy of Science; Franklin Institute; Medical Jour-